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SEDIMENTS

Subject:
Final Multi-Area Feasibility Study Technical Memoranda
Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site

Dear Mr. Saric:

Date:
March 31, 2010

On behalf of the Kalamazoo River Study Group (KRSRG), please find enclosed the final versions of two Multi-Area Feasibility Study Technical Memoranda – the *Preliminary Remedial Technology Screening* (Technology Screening Tech Memo) and the *Evaluation of Candidate Technologies and Testing Needs* (Technologies and Testing Needs Tech Memo).

Contact:
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These Tech Memos were originally submitted in February 2008 to satisfy the requirements of Task 1.2.2 of the Statement of Work (SOW) attached to the Administrative Settlement Agreement and Order on Consent (AOC) for the Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site (Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] Docket No. V-W-07-C-864). KRSRG revised and resubmitted both Tech Memos in January 2010 in response to U.S. Environmental Protection Agency (USEPA) comments, and USEPA approved those versions on March 24, 2010.

Our ref:
B0064524

If you have any questions, please do not hesitate to contact us.

Sincerely,

ARCADIS

Michael J. Erickson, P.E.
Associate Vice President

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**Allied Paper, Inc./Portage
Creek/Kalamazoo River
Superfund Site**

**Multi-Area Feasibility
Study Technical
Memorandum:
Evaluation of
Candidate
Technologies and
Testing Needs**

Kalamazoo River Study Group

March 2010





UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION 5

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REPLY TO THE ATTENTION OF:

March 24, 2010

Mr. Michael J. Erickson
Associate Vice President/Principal Engineer
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SR-6J

RE: Multi-Area Feasibility Study Technical Memorandum:
Evaluation of Candidate Technologies and Testing Needs

Dear Mr. Erickson:

The United States Environmental Protection Agency (EPA) has completed its review of the January 2010 final Multi-Area Feasibility Study Technical Memorandum: Evaluation of Candidate Technologies and Testing Needs for the Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site.

This technical memorandum has adequately addressed EPA's previous comments and incorporated them into the document. Therefore, EPA approves the final candidate technologies for a treatability studies program.

Please contact me at (312) 886-0992 if you have any questions regarding this matter.

Sincerely,

A handwritten signature in black ink, appearing to read "James A. Saric", is located below the "Sincerely," text.

James A. Saric
Remedial Project Manager
SFD Remedial Response Branch #1

cc: Paul Bucholtz, MDEQ
Gary Griffith, Georgia-Pacific
Richard Gay, Weyerhaeuser

**Allied Paper, Inc./Portage Creek/
Kalamazoo River Superfund Site**

**Supplemental Remedial Investigations/
Feasibility Studies**

**Multi-Area Feasibility Study
Technical Memorandum:**

Evaluation of Candidate
Technologies and Testing Needs

Kalamazoo River Study Group

March 2010



A handwritten signature in black ink, reading "Michael J. Erickson".

Michael J. Erickson, P.E.
SRI/FS Project Coordinator

A handwritten signature in black ink, reading "Stephen Garbaciak, Jr.".

Stephen Garbaciak, Jr., P.E.
Vice President

**Multi-Area Feasibility Study
Technical Memorandum:**

**Evaluation of Candidate
Technologies and Testing
Needs**

Allied Paper, Inc./Portage Creek/
Kalamazoo River Superfund Site

Supplemental Remedial
Investigations/Feasibility Studies

Prepared for:
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Ref.:
B0064524

Date:
March 2010

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1. Introduction	1-1
1.1 Multi-Area Feasibility Study Documents	1-1
1.2 Document Overview	1-3
2. Preliminary Candidate Technologies	2-1
3. Testing Needs for Candidate Technologies	3-1
3.1 General Evaluation of Candidate Technologies	3-1
3.2 Testing Objectives and Data Needs	3-3
3.3 Identification of Testing Needs	3-4
3.3.1 Typical RI/FS Process	3-4
3.3.2 Data Types	3-5
3.3.2.1 Characterization Data	3-6
3.3.2.2 Area-Specific Feasibility Study and Remedial Design Data	3-6
3.3.2.3 Treatability Study Data	3-6
3.4 Evaluation of Potential Benefit of Conducting a Treatability Study	3-7
3.4.1 No Action	3-8
3.4.2 Engineering/Institutional Controls	3-8
3.4.3 Monitored Natural Recovery	3-8
3.4.4 Removal	3-10
3.4.5 <i>In situ</i> Containment	3-12
3.4.6 Restoration-Based Remediation	3-13
3.4.7 Erosion Control	3-13
3.4.8 Sediment/Solids Dewatering	3-14
3.4.8.1 Mechanical Dewatering Processes	3-14
3.4.8.2 Gravity Settling Processes	3-14
3.4.9 Stormwater Management	3-15
3.4.10 Process Water Management	3-16

3.4.11	<i>Ex situ</i> Treatment	3-16
3.4.12	Waste Transport	3-17
3.4.13	Waste Disposal	3-18
3.5	Summary of Candidate Technology Process Options for Possible Further Testing	3-19
4.	References	4-1

Tables

1	Candidate Technologies and Process Options
2	Evaluation of Candidate Technology Testing Needs

Figure

1	Areas of the Site
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Acronyms and Abbreviations

AOC	Agreement and Order on Consent
ARAR	Applicable or Relevant and Appropriate Requirement
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CDF	Confined Disposal Facility
CSM	Conceptual Site Model
DQO	Data Quality Objective
DRET	Dredging Elutriate Test
°F	degrees Fahrenheit
FS	Feasibility Study
GLDT	Great Lakes Dredging Team
GRA	General Response Action
ISC	in situ capping
KRSG	Kalamazoo River Study Group
MDEQ	Michigan Department of Environmental Quality
mg/kg	milligrams per kilogram
MNR	monitored natural recovery
OU5	Operable Unit 5
PCB	polychlorinated biphenyl
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RD/RA	remedial design/remedial action
SAP	Sampling and Analysis Plan
SOW	Statement of Work
SRI	Supplemental Remedial Investigation
TOC	total organic carbon
TSWP	Treatability Study Work Plan
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency

1. Introduction

On February 21, 2007 Georgia-Pacific Corporation and Millennium Holdings, LLC—collectively referred to as the Kalamazoo River Study Group, or KRSG—voluntarily entered into an Administrative Settlement Agreement and Order on Consent (AOC) with the U.S. Environmental Protection Agency (USEPA) that will govern the majority of work from this point forward at the Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site (Site or Superfund Site), located in Kalamazoo and Allegan counties in southwest Michigan (Figure 1). The AOC describes a series of activities associated with supplemental remedial investigations and feasibility studies (SRIs/FSs) that will be carried out over the next several years in Operable Unit 5 (OU5) of the Site (SRI/FS AOC; Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] Docket No. V-W-07-C-864; USEPA 2007). OU5 encompasses 80 miles of the Kalamazoo River from Morrow Dam to Lake Michigan, including a stretch of Portage Creek from Alcott Street to its confluence with the Kalamazoo River.

The Statement of Work (SOW) included as Attachment A to the SRI/FS AOC specifies supplemental remedial investigations and feasibility studies to address polychlorinated biphenyls (PCBs) in seven Areas of OU5. The seven Areas in OU5 are shown in Figure 1.

1.1 Multi-Area Feasibility Study Documents

As described in the SOW, Area-specific feasibility studies (FSs) will be developed to support Area-specific risk management. The various FS activities that will be implemented by the KRSG will include examining potential general response actions and evaluating remedial technologies and alternatives to address impacts to human health and the environment using a risk-management approach consistent with the *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (USEPA 2005). The FS development activities will also be performed consistent with the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA 1988a) and *CERCLA Compliance with Other Laws Manual, Parts I and II* (USEPA 1988b; USEPA 1989).

To guide the FS work and provide for consistency and efficiency across the seven Areas of OU5, the SOW specifies preparation of several Multi-Area FS Planning Documents as the first step in the development of the FS reports. Per the SOW, these Multi-Area FS Planning Documents are intended to “set forth general approaches and concepts with the intent of streamlining preparation of work plans and minimizing review times for future deliverables” (USEPA 2007). An additional intention is to promote a consistent approach for completion of SRI/FS activities in each Area of the Site, as appropriate. The Area-specific work plans will incorporate the Multi-Area documents by reference, with appropriate Area-specific

modifications. Area-specific modifications may incorporate potential new information on expected land use, potential advances in remedial technology, information from new studies, or other information.

The four Multi-Area FS Planning Documents developed for the Site are described below.

- **Preliminary Remedial Technology Screening** – The first FS Planning Document includes the identification of general response actions and a preliminary list of remedial technologies to address contaminated soil, sediments, and groundwater in each Area.
- **Preliminary List of Possible Applicable or Relevant and Appropriate Requirements** – The second FS Planning Document identifies a preliminary list of possible state and federal applicable or relevant and appropriate requirements (ARARs), including chemical-specific, location-specific, and action-specific ARARs as appropriate. This preliminary list of possible ARARs may apply to the circumstances and array of potential remedies at one or more Areas.
- **Preliminary Permitting/Equivalency Requirements** – The third FS Planning Document provides a preliminary analysis of likely permit or permit equivalency requirements. The preliminary analysis focuses on substantive requirements of permits that may be applicable across the Site, and includes a discussion of potential waivers, as appropriate.
- **Candidate Technologies and Testing Needs** – This topic is the subject of this technical memorandum. In this document, a series of candidate technologies for a treatability studies program are identified that, per Section 4.1 of the SOW, will cover the “range of technologies required for alternative analysis.” This memorandum includes a compilation of literature information on the performance, relative costs, applicability, removal efficiencies, operation and maintenance requirements, and implementability of candidate technologies.

These Multi-Area FS Planning Documents were developed based on the understanding that the primary constituent of concern at the Site is polychlorinated biphenyls (PCBs) and the relevant contaminated media are in-stream sediments, bank soils, floodplain soils, and groundwater. The candidate technologies and process options evaluated in these planning documents do not include approaches specific to groundwater. If groundwater is identified as a medium of concern in a specific Area, technologies and process options and the associated testing requirement would be evaluated in that Area-specific FS Report.

1.2 Document Overview

This Multi-Area FS Planning Document, *Evaluation of Candidate Technologies and Testing Needs*, presents an evaluation of testing needs of the technologies and process options that have been retained following the preliminary screening process described in another Multi-Area FS Planning Document—*Preliminary Remedial Technology Screening* (Technology Screening Tech Memo; ARCADIS 2010).

This memorandum was developed in parallel with the *Technology Screening Tech Memo*, in which a range of technologies and process options were screened and retained using a preliminary remedial technology screening process. Technologies and process options retained after the screening step were then regarded as the “candidate technologies.” For each of these candidate technologies, an evaluation was performed as to its relative value or need for testing for the purpose of an FS. For those candidate technologies receiving a relative “high” or “moderate” value for testing, further testing is generally recommended to be conducted during the development of the Area-specific FS Reports, if applicable to the Area. Specific testing procedures will be evaluated, defined, and presented in the Treatability Study Work Plans (TSWPs) and Sampling Analysis Plans (SAPs), as appropriate, according to the SOW.

Section 2 of this memorandum identifies and discusses these retained candidate technologies relative to their effectiveness and implementability. Section 3 identifies any treatability testing that may need to be conducted prior to completing the FS process in a particular Area of OU5. Section 4 provides a list of references cited in this memorandum and presents the sources identified during the literature review.

2. Preliminary Candidate Technologies

This section presents the candidate technologies that are potentially applicable to one or more Areas of the Site. Consistent with the guidelines and principles of the USEPA's Sediment Guidance (USEPA 2005), each of the three major sediment remediation approaches (dredging, capping, and monitored natural recovery [MNR]) is considered as a possible general response action (GRA) and evaluated for the Site (ARCADIS 2010). Associated with these three major sediment remediation approaches, a range of remedial technologies and process options were subjected to a preliminary remedial technology screening process (ARCADIS 2010). The options retained after this step are the "candidate technologies and process options" and are presented in Table 1. The candidate technologies and process options are medium-based response actions that were selected to satisfy an assumed range of potential remedial action objectives (RAOs). The rationale for the development and screening of these candidate technologies and associated process options are presented in the Technology Screening Tech Memo (ARCADIS 2010).

Given the size, complexity, and variability of characteristics throughout the Site, there is no one presumptive remedy for the Site or any Area of OU5. As a result, FS activities for the Site will be conducted in an iterative approach to allow reevaluation and modification as Area-specific CSMs and RAOs are refined and additional knowledge of remedial technologies becomes available. As part of this process, a variety of possible combinations of the remedial technologies and process options presented in Table 1 will be assessed during the evaluation and assembly of an appropriate range of potential remedial alternatives for each Area. The most effective remedy for an Area is likely to consist of a combination of technologies/process options.

3. Testing Needs for Candidate Technologies

This section presents a preliminary evaluation designed to assess whether or not a treatability study is necessary for each of the retained candidate technologies or process options (described in Section 2 and shown on Table 1) for the purpose of completing Area-specific FS Reports. As part of this evaluation, a relative “value or need for treatability study” was assigned for each candidate technology or process option, as shown in Table 2. For those receiving a relatively “high” or “moderate” value or need, further testing is generally recommended to be conducted before or during the development of the Area-specific FS process, depending on the scope and content of the FS for each specific Area.

In the subsections that follow, the general evaluation of the candidate technologies is summarized (Section 3.1), the general testing objectives and data needs are described (Section 3.2), the available data and information used to assess testing needs is summarized (Section 3.3), and the evaluation of testing needs is described (Section 3.4). A summary of the candidate technology process options recommended for possible further testing is presented in Section 3.5.

3.1 General Evaluation of Candidate Technologies

A general evaluation of technology characteristics has been conducted based on information gathered through a literature survey as well as professional judgment based on relevant experience from this and other sites. The literature survey was conducted to gather information on the candidate technologies’ applicability, performance (or effectiveness), implementability at the Site, PCB removal efficiencies, operation and maintenance requirements, and relative costs. References consulted during the literature survey are provided in Section 4.

In addition to the literature survey and experience reported at other relevant sites, the experience and knowledge gained from the prior full-scale actions taken at the Kalamazoo Site over the past decade have provided a base of knowledge regarding removal, handling, and disposal of PCB-containing soils and sediments, and regarding control and monitoring of conditions around and adjacent to removal areas. The direct experience with full-scale implementation of removal actions in other locations (e.g., the former Plainwell Impoundment and the Plainwell No. 2 Dam Area) provides valuable Site-specific testing data for evaluating the feasibility of the similar removal technologies and process options that may be considered for the downstream impoundments. The recently completed TCRA in the former Plainwell Impoundment (ARCADIS BBL 2007) and the TCRA underway in the Plainwell No. 2 Dam Area (ARCADIS 2009b) are also sources of important information on the implementability and effectiveness of bank soil removal and bank stabilization, near-shore and mid-channel sediment removal, and the

selected turbidity and water quality control technologies. Other source control work that has been performed at the former Mill Properties and disposal areas (as summarized in the Generalized CSM [ARCADIS 2009a]) provides additional Site-specific data on the effectiveness and implementability of the removal technologies employed and the associated process options.

The remedial activities that have been implemented at the Site have generated a wealth of full-scale data that is typically not available when developing an FS. These data also provide information that is critical to understanding potential implementability, effectiveness, and relative costs as part of the evaluation of technologies or process options during Area-specific FSs. As discussed below, circumstances at an individual Area of the Site may indicate potential benefits of treatability testing to support that FS. Further, any future remedial activities that are implemented at the Site will provide data that may inform the subsequent development of an Area-specific FS.

The general characteristics of the identified candidate technologies and associated process options are summarized in Table 1. Note that additional information on the description, effectiveness, and implementability of individual candidate technologies are presented in the *Multi-Area Feasibility Study Technical Memorandum: Preliminary Remedial Technology Screening* (ARCADIS 2010).

The criteria of the qualitative general evaluation are described below.

- **Applicability** – The applicability of each technology process option was evaluated qualitatively based generally on its feasibility to address the specific type of contaminant (i.e., PCBs), medium of concern (i.e., in-stream sediment or bank/floodplain soils) or the process streams (e.g., process water, dredged material) that would be generated by a candidate technology (e.g., sediment dredging).
- **Performance or Effectiveness** – The performance or effectiveness of each technology process option was evaluated qualitatively based on: (a) its general ability, when applied alone, to reduce or interrupt the exposure potential by human and/or ecological receptors to PCBs in sediment or soil (or, in the case of banks or floodplain soils, to prevent or control erosion of riverbank and floodplain soils); and (b) the extent to which it can sustain effectiveness for its intended purpose.
- **Implementability** – The implementability evaluation included consideration of both the technical and administrative feasibility of implementing a technology process option as well as the availability of equipment, materials, and personnel to implement the process option.

The evaluation of implementability also considered Site conditions and characteristics that would potentially limit or challenge the use of the candidate technology and process options.

- **Operation and Maintenance Requirements** – The effectiveness of each technology process option was evaluated qualitatively based on: (a) its general ability to reduce the potential for human or ecological exposure to PCBs in sediment or soil (or, for the banks or floodplain soils, to prevent or control erosion of riverbank and floodplain soils); and (b) the extent to which long-term maintenance or monitoring is required to ensure effectiveness.
- **Relative Costs** – The relative cost of each technology process option was rated qualitatively based on the overall cost for implementing a particular technology process option relative to other process options within the same technology group.

These characteristics are important considerations for screening and evaluating potential technologies or process options. During the development of Area-specific FSs, these and other criteria will be further evaluated for each potential Area-specific remedial alternative that may consist of one or several combined technology process options. As a result, the effectiveness of a technology or process option may increase when paired or combined with other technologies to meet identified RAOs.

For those candidate technologies or process options that were retained after the screening process, quantitative data may need to be collected to aid the alternative evaluation through further testing or treatability study. Types of testing and testing data, and the evaluation of the testing needs for the retained technologies or process options are presented below. The need for testing and type of testing data will be evaluated and refined during the development of Area-specific SRI work plans and FS Reports.

3.2 Testing Objectives and Data Needs

In general, the main objectives of testing in the FS phase are to determine if a candidate technology or process option is appropriate for addressing relevant environmental media, and can meet (or assist in meeting) identified ARARs and/or RAOs. For each candidate technology or process option evaluated in Section 3.4, the data needs for testing are identified as appropriate. This is useful for streamlining the process of obtaining the necessary quantitative information for achieving the testing objective.

This document provides a preliminary evaluation of the testing needs for the candidate technologies or process options for the purposes of conducting each Area-specific FS that are

potentially applicable to one or more Areas of the Site. When a testing need is identified, the data needs for achieving the testing objective are described. Because the Site is large and conditions vary considerably from one Area to another, a phased and adaptive approach to characterization and alternative evaluation is necessary. For this reason, specific data needs or requirements will be evaluated and refined during the Area-specific characterization and FS processes. In addition, during the Area-specific FS process, the applicability and effectiveness of the candidate technologies and process options will be considered in an iterative manner by assessing the testing data needs and evaluating the data collected from the treatability studies.

The remainder of this section describes the key criteria for the evaluation of the candidate technologies, presents the types of testing and data needs, and evaluates the potential benefit for conducting a treatability study for each candidate technology or process option.

3.3 Identification of Testing Needs

The identification and initial evaluation for testing needs typically relies on literature reviews and an understanding of how various technologies and process options have been applied at this and other sites. RI data are often sufficient to allow generalized conclusions regarding the applicability of various technologies or process options to address impacted Site media. However, the further screening and selection of remedial alternatives may require additional data generated from site-specific treatability studies to allow the evaluation of implementability, performance, sizing, and costs for the facilities being considered.

3.3.1 Typical RI/FS Process

Treatability testing is typically considered at various stages of the RI/FS process:

1. Technology Prescreening and Treatability Study Scoping – Technology prescreening and treatability study scoping may include searching technology literature and treatability databases, consulting with technology experts, determining data needs, identifying potential treatability study sources or contractors, and identifying preliminary data quality objectives (DQOs). These activities may precede or be conducted concurrently with the technology and process options screening.
2. Remedy Selection Testing – Remedy selection treatability studies are designed to verify whether various process options can meet the required cleanup criteria and at what cost. The purpose of this testing is to generate the critical performance and cost data necessary for remedy evaluation in the detailed analysis of alternatives during the FS.

While process operating parameters are investigated during the remedy selection testing, investigation of equipment-specific parameters is generally deferred until remedial design/remedial action (RD/RA) testing (described below).

3. RD/RA Testing – RD/RA treatability studies are performed to generate the detailed design, cost and performance data necessary to design, optimize and implement the selected remedy. These studies are performed to select appropriate processes and vendors, design and implement an effective remedial alternative, and support the detailed design specifications and design of treatment trains (USEPA 1992).

Treatability studies may be performed as “generic” studies for widely-available processes and chemicals or “vendor” studies for specialized treatment systems or the application of proprietary chemical reagents. “Generic” processes may be implemented by competitive procurement. “Vendor” studies may generate high-quality quantitative data and establish optimal performance or promote the use of innovative technologies.

Most of the described testing types in this document would be considered “generic,” as they address the effectiveness of non-proprietary candidate technologies or process options using Site-specific media (e.g., sediment). “Vendor-specific” testing may be considered for certain process options (e.g., use of proprietary solidification reagents applied to floodplain soils).

For the purpose of this document, the need for a treatability study for a candidate technology or process option is evaluated to answer this question: Will further testing improve the ability to determine the implementability and/or effectiveness of this candidate technology as a potential remedy or a component of a remedy for an Area of the Site? For example, is sufficient information already available to determine that sediment capping would be a viable candidate technology in one or more Areas, or is further testing needed to make that determination? Conversely, treatability testing is not considered necessary for those remedial technologies that are widely used and proven (e.g., treatment of process water) based on the literature review and experience at this and other sites.

3.3.2 Data Types

The screening and preliminary evaluation of technologies and process options rely on the data collected as part of the various investigations and remedial design work previously conducted at the Site. Existing data that will be considered during the FS process are briefly described below.

3.3.2.1 Characterization Data

Site data presented in the USEPA-approved *Generalized CSM* (ARCADIS 2009a) document PCB levels in water, sediment, soil, and biota samples collected throughout various identified reaches, matrices, and depth intervals. Ranges, averages, and spatial distributions of PCB concentrations are presented as are statistics for several physical and chemical characteristics (total organic carbon [TOC], percent solids, grain size distributions, and bulk density). The nature and extent of PCBs in sediments are summarized for vertical and areal distributions in various reaches.

These characterization data are useful in screening the applicability of various technologies and process options. However, the range of soil and sediment characteristics and volumes to be treated will not be known until specific cleanup goals are determined. In addition, the ability of various treatment technologies to achieve alternative cleanup goals can only be estimated at this time based on the existing data.

3.3.2.2 Area-Specific Feasibility Study and Remedial Design Data

The final selection and design of Area-specific alternatives often requires the collection of site-specific data to allow development of performance and sizing criteria as well as costs for the processes being considered. These data are to be generated from site-specific testing or studies and will be evaluated during Area-specific FS and RD phases.

The materials collected for Area-specific FS and RD testing should be obtained from, or represent, the specific locations that will be addressed by the selected remedial actions. Sample collection should consider the range of material properties that will be encountered during the RA. For instance, the composition of dredged or excavated materials to be applied in treatability tests should also simulate the dilution or mixing that may take place using specific dredging or removal technologies. Simulated mixtures of site water and sediments should be freshly prepared to best represent the expected elapsed time between excavation and treatment.

3.3.2.3 Treatability Study Data

The candidate technologies and process options retained after the screening process are potentially feasible and could prove to be effective based on application at other sites, but their implementability and effectiveness for a particular Area at the Site may be uncertain or warrant further testing. Treatability studies for the purpose of completing Area-specific FSs would allow

further assessment of their applicability with a greater degree of certainty. The benefit from this type of treatability testing is the focus of the remainder of this document.

As described in Section 3.3.1, treatability studies are designed so that the project team can collect data that would provide a greater degree of certainty in evaluating the effectiveness and implementability of candidate technologies based on the specific media and conditions present in a particular Area. Specific data needs for an Area will be identified during the development of that Area-specific FS Report.

3.4 Evaluation of Potential Benefit of Conducting a Treatability Study

The following subsections provide a brief description of the considered candidate technologies and process options. Table 2 presents a summary of the identified potentially beneficial treatability studies for the screened candidate technologies. For each candidate technology and process option, the relative value of or need for a treatability study for the purpose of FS has been assigned as low, moderate, or high. For those technology and process options where the relative value of or need for treatability studies is high or moderate (as shown in Table 2), the basis and objectives for testing are presented. Because the RAOs and cleanup goals for each Area of the Site will be developed in the future, the testing needs and type of data to be collected will be evaluated, defined, and presented in the Area-specific Treatability Study Work Plans (TSWPs) and Sampling Analysis Plans (SAPs), as appropriate, according to the SOW (USEPA 2007). The TSWP and SAP components typically include, but are not limited to, testing objectives, experimental procedures, testing conditions, performance measurements, analytical methods, health and safety, residual waste management and the study schedule.

At this stage in FS planning, the need for a treatability study for a particular technology option is determined primarily in consideration of known Site conditions, implementability of the technology to address the media of concern, reliability and maturity of the technology, overall application success or effectiveness of the technology at similar sites (e.g., contaminant type, medium characteristics, hydraulic characteristics). For example, technologies such as engineering/institutional controls involve physical restrictions to access by conventional means (e.g., a perimeter fence or signage) or require the implementation of administrative tools to restrict land use or biota consumption; as such, treatability studies for this technology would not be necessary. In other cases such as treatment of processed water, a treatability study may not be necessary because the water treatment technology has been widely used and has proven to be reliable.

If a treatability study for a particular candidate technology or process option is not identified as providing a benefit as the result of this preliminary evaluation, this does not preclude the need

for data collection related to this technology prior to its implementation during the RD phase. In the example of a water treatment system, testing data will be necessary to size the treatment system capacity and verify the technology's ability to achieve the performance goals or meet discharge requirements prior to the actual operation and discharge of treated water.

3.4.1 No Action

The National Contingency Plan requires that a no action alternative be considered at every site (40 CFR 300.430(e)(6)). The no action response action takes into account ongoing natural attenuation in sediments and soils but would not include any long-term monitoring or controls. It is appropriate in areas of a site that already meet cleanup goals, and thus can be a component of the selected remedy. Treatability studies would not be performed for no action areas.

3.4.2 Engineering/Institutional Controls

Engineering/institutional controls may include, but are not limited to, physical access restrictions (such as fences and signs), activity and use restrictions (including deed restrictions), and information devices (such as biota consumption advisories). Treatability studies would not be performed for engineering/institutional controls.

3.4.3 Monitored Natural Recovery

Monitored natural recovery (MNR) is a response action that actively evaluates ongoing natural processes that contain, destroy or convert contaminants to less toxic forms, reduce contaminants bioavailability and mobility, and reduce contaminant exposure level through burial or mixing-in-place with cleaner material or other transport means in sediment. USEPA recommends evaluation of MNR as a possible remedial technology for all major sediment sites to reduce risk to human and/or ecological receptors (USEPA 2005). Treatability studies to examine, monitor, and simulate various natural recovery processes could be performed as part of the evaluation of MNR. Because MNR may rely on a wide range of naturally occurring processes to achieve risk reduction, the effectiveness of MNR as a potential remedy or a component of a remedy is typically evaluated based on multiple lines of evidence, potentially including:

- Trends of contaminant levels in higher trophic level biota (e.g., piscivorous fish)
- Trends of water column contaminant concentrations

- Depositional histories reflected in sediment cores
- Trends in surface sediment contaminant concentration, sediment toxicity, or contaminant mass within the sediment (USEPA 2005)

In addition, the sedimentation dynamics as monitored through repeat bottom elevation surveys, sedimentation markers, sediment traps, or other methods can play a key role in understanding how sedimentation processes affect sediment stability and natural recovery.

The evaluation of MNR in the context of a Treatability Study could seek to monitor appropriate indicators to assess the general effectiveness of natural processes over time and to compile a data record of utility to the evaluation of MNR in specific Areas of the Site in advance of specific FS activities for those Areas. For example, collecting data on PCB congener patterns and other relevant field parameters in Lake Allegan sediment over time may allow an assessment of the degree and contribution of the naturally occurring PCB dechlorination or biodegradation to the overall reduction of exposure risk. Previous studies (Envirogen, Inc. 1994; BBL 2000a and 2000b) have discussed the potential for dechlorination mechanisms in Kalamazoo River sediments. Implementation of appropriate monitoring designed specifically to evaluate MNR where appropriate, will allow stronger conclusions relative to implementability, effectiveness, and other relevant CERCLA criteria.

The mechanisms, rates, and data sets for MNR evaluation will vary considerably by Area based on the fate of dams and differences between free-flowing and impounded sections of the river. In some cases, such as areas where dams have been removed, MNR evaluations may be much different than in Areas where dams are being maintained in place. Prior long-term monitoring activities at the Site will continue and provide a key basis for Area-specific MNR evaluations, as well as Site-wide evaluations. An assessment of data needs with respect to the viability of MNR may be addressed in the development of Area-specific SRI work plans and/or presented in Area-specific FS Reports. Modeling studies may be needed to describe the fate and transport of PCBs within the river system and to evaluate the long-term effectiveness of MNR.

Natural recovery process may be accelerated or enhanced by engineered means, for example by the addition of a thin layer of clean sediment or sand in a process sometimes referred as “thin-layer placement” (USEPA 2005) or by placing structures in the river to enhance sedimentation.

Enhanced MNR via **thin-layer placement** involves placing a thin layer of clean material over contaminated sediment to accelerate natural recovery. Bioturbation may serve to integrate this

clean layer with existing sediments, thereby reducing PCB exposure concentrations in the surface sediment. Thin-layer placement is different from isolation capping because it is implemented to support and accelerate an ongoing natural recovery process rather than being specifically designed to provide long-term isolation by itself (USEPA 2005). While the thickness of an isolation cap can range up to several feet, and the cap components are specified based on the chemical and physical characteristics of the contaminated sediment, thin-layer placement can consist of as little as a few inches of clean material. Because thin-layer placement typically creates fewer short-term environmental impacts than isolation capping, the benthic population – which is inevitably disturbed during the clean layer placement – can reestablish itself faster than it would with engineered capping or removal remedies.

A treatability study may be useful when considering thin-layer placement to enhance MNR for contaminated sediment. Treatability study considerations for thin-layer placement option are similar to those used to assess the applicability and effectiveness of MNR and may include studies to assess concentration trends, depositional characteristics, bathymetric change, bioturbation potential of native benthos, and long-term sediment stability.

Natural recovery in aquatic environments can also be accelerated by increasing the sediment deposition rates in selected areas; this is often referred to as **enhanced sedimentation**. Enhancing sedimentation in a river can be accomplished by placing natural or artificial structures to disrupt the river's flow in such a way that sediment will settle out of the water column in selected areas. The increased sediment deposition rates in these selected areas serve to isolate underlying, contaminated materials from the water column. Enhanced sedimentation can be less disturbing to the localized environment and benthic communities than thin-layer placement because the sedimentation occurs over a longer timeframe.

3.4.4 Removal

Removal involves the physical dredging (mechanically or hydraulically) or excavation of PCB-containing sediments, bank soils or floodplain soils. It is important to understand that removal is an integration of dredging or excavation with transport, treatment, and disposal. Several removal methods are discussed below.

Mechanical dredging in the wet involves removing PCB-containing sediment using conventional equipment (e.g., clamshell bucket, environmental bucket) through the water column. Barge-mounted equipment is typically used, and engineering controls (e.g., silt curtains and/or water level controls) may be used to minimize the migration of sediments beyond the targeted work area. Mechanically dredged materials are typically transferred to a truck or container on a barge and transported to a land-based processing facility. Alternatively,

mechanical removal can be performed using earth-moving equipment working from land if access is available.

Excavation in the dry involves removing PCB-containing sediment using conventional excavation equipment (e.g., an excavator) after dewatering the removal area (e.g., via pump bypass, rechannelization, or cofferdam installation). Excavation in the dry can be performed by staging earthmoving equipment along the bank of the river and/or placing such equipment in the dewatered area of the river. Excavated materials may be placed in trucks or other transport units (for subsequent transfer to a processing facility) or transferred directly to a processing area if it is nearby.

Hydraulic dredging uses a hydraulic pump or compressed air to create a vacuum at the dredgehead to remove sediments. Some types of hydraulic dredges include the horizontal auger, cutterhead dredge, and the PNEUMA pump. The removed sediments are then transported to lagoon or basin in a liquid slurry via pipeline for dewatering and further treatment (i.e., stabilization, solidification) in preparation for disposal. The dredging equipment is most often barge-mounted. Implementation of hydraulic dredging requires sufficient water depth to support the movement and operation of the dredge and appurtenances in the river. The hydraulic process typically introduces a large amount of water to the removed sediments, with typically a five percent solids content expected for most environmental dredging projects (USEPA 2005). Because a large amount of water is generated, consideration of the applicability of this approach must include an assessment of whether sufficient space is available near the dredge area to stage sediment dewatering and processing equipment. The effectiveness and efficiency of hydraulic dredges are greatly impacted by the presence of debris in the sediment. Engineering controls for minimizing suspended sediment transport during dredging would be required.

Removal with or without Replacement. Removal technologies have been used at a number of contaminated sediment sites, but there are limitations associated with removal (NRC 2007), and post-removal residual contaminant levels may require additional management in some cases. Capping or placement of cover materials over dredged or excavated areas to cover residual concentrations of contaminants has been used for some environmental dredging projects (NRC 2007). Residual cover layers may also be placed in conjunction with placing backfill in the dredged or excavated area to restore pre-removal bottom elevations where necessary. For the purpose of determining whether a particular removal technology alone is feasible or not, a treatability study would generally not be necessary due to the state of knowledge concerning dredging technologies; however, the effectiveness of dredging in meeting remedial goals can be highly variable depending on site characteristics. Other studies may be conducted during the FS to aid the assessment of the impact or potential risk

generated by a removal technology during its implementation. For example, the short-term resuspension of contaminated sediment due to dredging can be studied to evaluate the bioavailability of contaminants via the water column using the Dredging Elutriate Test (DRET). These results will allow conclusions to be reached regarding the protection of human health and the environment and other relevant CERCLA criteria. Descriptions of the elutriation tests can be found in the Upland Testing Manual (United States Army Corps of Engineers [USACE] 2003).

In 2005, a modified DRET test method was developed by Rice University and used to evaluate the bioavailability of metal contaminants at the Trepangier Bayou and Anacostia River sites (Shipley et al. 2005). This study concluded that the modified DRET test in comparison with the standard DRET test provides better prediction of metal bioavailability during resuspension. For the same reason, as science and technologies continue to be developed and improved and knowledge and experience are gained, testing needs will be reevaluated in an adaptive manner during the development of Area-specific FSs.

3.4.5 *In situ* Containment

In situ containment involves the active placement of clean cover materials over river sediments or exposed soils. *In situ* containment through capping is increasingly used as a remedy component at sediment sites. The primary functions of this technology include physical isolation, stabilization, and chemical isolation of contaminated sediments sufficient to reduce exposures to contaminated sediments and/or pore water by potential human and ecological receptors. *In situ* capping technology options considered include *in situ* capping (ISC), clean soil cover (for bank or floodplain soils), and engineered barriers for sediments and soils. PCBs in the bank and floodplain soils can also be contained with capping and/or barrier walls. Caps for sediment or soils can be a clean sediment, sand, or soil layer or a multi-layer engineered barrier.

Treatability studies are generally not necessary for the purpose of determining whether or not capping is a feasible technology. Capping is a proven technology that is widely-used at various sediment sites (<http://www.sediments.org/capping-chart.html>). For example, Horne Engineering Services, LLC (Horne) constructed a series of reactive caps (AquaBlok™, coke breeze, and apatite) in the Anacostia River in 2004 to demonstrate and evaluate subaqueous active capping technologies. Post-cap monitoring implemented at this site verifies the integrity and performance of the caps and recolonization of benthic organisms (Horne 2007). However, pilot-scale studies may be conducted during the FS to assess innovative capping materials or site-specific conditions. These results will allow conclusions to be drawn regarding implementability and other relevant CERCLA criteria.

3.4.6 Restoration-Based Remediation

In situ restoration-based remediation may achieve risk-reduction goals in floodplain soils by reducing the bioavailability of PCBs in conjunction with improving fertility and habitat quality through the application of soil cover, and addition of various soil amendments and/or PCB-binding natural organic materials. Restoration-based remediation measures may also include phyto-remediation—a range of processes mediated by vegetation planted in the zone targeted for action—an approach that could have the added benefit of promoting habitat development. Soil improvements and fertility enhancements may be implemented by placing/tilling clean soils into surface floodplain soils or adding fertilizing agents or other suitable materials. Treatability studies may be necessary to assess the soils that will be used for restoration-based remediation, to evaluate the effectiveness of different amendments, or to assess site-specific conditions or plant species for phyto-remediation. These results will allow conclusions to be drawn regarding implementability and other relevant CERCLA criteria.

Types of *in situ* restoration-based remediation technologies are being implemented and studied full-scale as part of the two TCRA projects near Plainwell. The data obtained during the implementation of these actions provides full-scale study data that are potentially relevant to other Areas of the Site. Other types of restoration-based remediation may be envisioned for certain Areas of the Site, including exposed sediments of the former impoundments, if appropriate. In Table 2, the Relative Value or Need for Treatability Study for the *in situ* restoration-based technologies is rated “moderate” rather than “high” to account for the fact that data needs are reduced by the full-scale TCRA projects. In addition, the effectiveness of various approaches may need to be determined through application and monitoring rather than through pre-FS studies, given the time frames involved to evaluate effectiveness.

3.4.7 Erosion Control

Bank stabilization is a common practice used in aquatic environments to prevent or control erosion. It typically involves the construction of structures that stop wave energy from reaching the natural riverbank or structures that absorb and reflect the wave energy. Riprap, armor stone, revetment mats, retaining walls, gabions, and vegetation covers are considered as candidate bank stabilization options. Because the technologies used for bank stabilization are commonly used in navigational and environmental fields, treatability studies are not needed to evaluate these options.

Restoration-based measures may be applied to control soil erosion. Soil caps or covers may be applied to riverbanks or floodplains to control PCB sources (e.g., exposed sediment in former impoundments) by isolating or reducing the mobility of PCBs in the bank and floodplain

soils. Soil amendments may be applied or mixed into these soil caps or covers to improve the fertility of the soil cover and to promote the growth of desirable vegetation and habitat; vegetation on the soil cap or cover will further aid in controlling erosion. Treatability studies may be necessary to assess soils used for caps or covers, to evaluate the effectiveness of different amendments, or to assess site-specific conditions. These results will allow conclusions to be drawn regarding implementability and other relevant CERCLA criteria.

3.4.8 Sediment/Solids Dewatering

Solids dewatering is used to remove excess water from dredged sediments or saturated soils to facilitate their handling and treatment/disposal in conjunction with sediment and soil removal technologies. Dewatering is typically performed using some combination of mechanical and/or gravity-assisted techniques. Treatability studies are not typically needed during the FS. Sizing and confirmatory testing may be conducted during remedial design for a particular process. Descriptions of the candidate dewatering options are presented below.

3.4.8.1 Mechanical Dewatering Processes

Belt filter press operation involves feeding gravity-dewatered materials between two continuous belts, one above the other. Pressure is applied to the belts to dewater the solids, yielding an aqueous filtrate. The dewatered solids are continuously removed from the belt by a scraper. Effluent from the process may require treatment prior to discharge to surface water. Following treatment, solids would be subject to a disposal option.

Plate and frame filter press operation consists of a series of plates and frames held together using a hydraulic ram. Dredged material (which can be chemically conditioned to enhance filterability) is pumped into the space between the plates within the frames. Water is forced through filter media on the plates and out the plate outlets, which yields a dilute aqueous filtrate. The dewatered solids are then removed by separating the plates and frames. An optional membrane filled with compressed air can be used to effect further dewatering. Effluent from the process may require treatment prior to discharge to surface water. Following treatment, solids would be subject to a disposal option.

3.4.8.2 Gravity Settling Processes

Various methods are available that employ gravity dewatering techniques to increase the solids content of wet sediments and soils. These methods include stockpiling, use of a thickener, placement of material in a settling basin, and use of geotubes.

A **stockpile approach** involves placing the removed sediment and soil in an onsite stockpile, where free liquids would be allowed to gravity drain. The liquids would be collected within a sump for proper treatment/disposal. The stockpile area would be lined and bermed to contain solids and liquids. Materials placed within the stockpile would remain until the moisture content was sufficiently low to allow for further processing/treatment or for transport and disposal.

A **thickener approach** involves dewatering the removed sediment and soils by allowing solids to settle by gravity within a circular tank, where the sediment consolidates at the bottom. Pretreatment with chemical additions, such as flocculants, may be used to enhance the settling of the slurry and to expedite the thickening process. Water from the top of the circular tank can be removed and treated, if necessary, prior to discharge to surface water. The settled solids would most likely require additional treatment to be sufficiently dewatered to allow offsite transportation.

With a **settling basin**, wet sediment or soil would be placed in a basin where the solids would be allowed to settle, drain, and consolidate in the bottom of the basin. Pretreatment with chemical additions such as flocculants may be used to enhance the settling of the slurry and to expedite the consolidation process. Basins may consist of prefabricated tanks or structures constructed at the work site using portable equipment, creating a temporary, lined structure capable of containing a shallow liquid/solids pool. Clarified water would be either treated or discharged directly to surface water. Settled solids would likely require further treatment to reduce moisture content; this further treatment would most likely involve an additional technology/process option.

A **geotube option** would involve pumping the sediment slurry into fabric tubes, which would help to consolidate the slurry as liquids are forced out through the fabric matrix. Upon being forced out of the geotube, liquids would be collected for proper treatment/disposal, followed by discharge to surface water. Consolidated solids would be removed from the geotube for subsequent management.

3.4.9 Stormwater Management

Stormwater management involves physically managing stormwater via collection with treatment or diversions. Treatability studies beyond the data collected during the testing of process water management options (described below) are not typically used to evaluate these options.

3.4.10 Process Water Management

Process water removed during dewatering or other processing operations will most likely need to be treated to meet discharge criteria. Processes may include chemical flocculation and settling, followed by multimedia filtration and activated carbon adsorption. In rare situations, ultrafiltration may be needed for final polishing. These processes have a considerable history of use in controlling PCB discharges. Treatability tests are not needed for feasibility studies, but sizing and confirmatory testing may be performed during remedial design.

3.4.11 *Ex situ* Treatment

Removed sediments or soils may be further treated by physical, chemical, or thermal methods to isolate or destroy chemical constituents. The identified candidate process options for *ex situ* treatment are presented below.

***Ex situ* stabilization/solidification** involves mixing the removed materials *ex situ* with cement, fly ash, kiln dust, or some other stabilization agent. This process option may be used for dewatering only (e.g., to facilitate the vehicular transport of materials), to reduce the leachability (i.e., mobility) of the chemical constituents, or to modify the material's structural properties (compressive strength) to make it more compatible with disposal or beneficial reuse. This process option may be combined with a disposal option that requires a stabilized material with a low moisture content. Depending on the stabilizing agent, mixing can occur within a lined work area, in a container (such as a mix box), or in dedicated processing equipment that agitates or rotates the sediment/soil and treatment material.

Particle separation refers to a process that physically separates finer-grained PCB-containing particles from coarser-grained particles through particle size separation techniques. The most commonly used technique for particle size separation is soil washing. During soil washing, sediment and soil would be passed through screens/sieves, mixing blades, and water sprays. Hydrocyclones and/or gravity separation could also be used. This process would wash silt and clay from the larger-grained soil, separating these materials. The wash water would be collected and treated in an onsite treatment system for reuse in the scrubbing process.

The fine particles, which typically contain proportionally higher PCB concentrations, are retained for further treatment or disposal. The coarse fraction may possibly be reused (e.g., as backfill) following confirmation that applicable standards are achieved. The coarse fraction may also be rewashed in an effort to allow reuse. Overall, soil washing could provide a mechanism for reducing the quantity of PCB-impacted sediment and/or soil requiring disposal. It could also potentially reduce the cost for disposal by segregating the material into fractions with PCB

concentrations ≥ 50 milligrams per kilogram (mg/kg) and < 50 mg/kg, which may allow approval for the latter to be disposed of at a conventional solid waste disposal facility. Further, for sediments with variable grain size, separating out the sands/gravels from the finer-grained materials can also be used as a dewatering pretreatment step to help save time and cost if a plate and frame or belt press is being used to dewater the sediments.

Chemical extraction refers to a process that involves the mixing of an extraction fluid/solvent with the removed sediment and soil to remove or desorb PCBs from the solid media into the extracting fluid. Extraction fluids used in this process may consist of common chemicals or proprietary products. Extraction fluids that have been used for PCB treatment include acetone, kerosene, liquefied carbon dioxide, propane and other hydrocarbons, and methanol.

Thermal desorption physically separates the PCBs from the sediment/soil by adding heat to the material to volatilize the PCBs, which are subsequently condensed/collected as a liquid, captured on activated carbon, and/or destroyed in an afterburner. Heating is typically accomplished by indirectly fired rotary kilns, a series of externally heated distillation chambers, heated screw conveyors, or fluidized beds (USEPA 1991). The boiling points for PCBs generally range from 644 to 707 degrees Fahrenheit ($^{\circ}\text{F}$); therefore, the thermal desorption treatment needs to reach temperatures higher than this range in order to effectively volatilize PCBs. Removed liquid PCBs would require treatment/disposal. Soils/sediments treated with temperatures higher than 600°F usually do not contain any free organic material, which makes them suitable for backfill. However, these treated solids may not be able to support microbial life, which may limit potential application.

Over the past decade, these *ex situ* solids treatment technologies (e.g., BioGenesisSM Sediment Washing Technology) have been tested and applied at remediation sites (Stern 2006; USEPA 1999; USEPA 2006; Wilk 2003; Wilk 2005). Because these technologies are generally well understood, treatability studies are not needed to assess the feasibility of the technologies. Testing is typically performed during the design phase to collect data for equipment selection and sizing.

3.4.12 Waste Transport

Transport processes are used to deliver dredged or excavated sediments to processing or staging areas (by truck, rail, barge or pipeline) and for delivering treated or untreated sediments to final disposal facilities (by truck, rail, barge or pipeline). Treatability tests are not needed for feasibility studies, but testing may be performed during remedial design to confirm that the transported materials will be stable and will not separate during transport.

3.4.13 Waste Disposal

Removed sediments or soils may be deposited near the Site using in-water or on-land confined disposal facilities (CDFs) or in offsite permitted disposal facilities. Characterization testing of residuals from other process simulations may be required to confirm that the disposed residuals can meet physical or chemical restrictions to be compatible with the final disposal requirements.

In-water CDFs would be constructed to accommodate removed sediment and soil so as to permanently isolate PCB-containing material from the aquatic environment. This facility (or facilities) would be constructed within the river basin at a location (or locations) selected to receive materials from as wide a segment of the river as needed, while transporting the material over as short a distance as practical.

On-land or in-land CDFs, which are assumed to be constructed in close proximity to the river, are designed to allow removed solids to gravitationally separate, settle, and consolidate. CDFs may be required to operate over an extended length of time depending on the period required for sediment removal. After operation, the CDFs would likely be capped, graded, and seeded. CDFs typically include liners, barrier layers, and leachate collection and detection systems.

CDFs have been used at other sites with PCB-impacted sediment and floodplain soils. CDFs have been widely used for disposing of sediments dredged from navigation channels. The Great Lakes Dredging Team (GLDT) reported that the USACE has constructed 43 CDFs around the Great Lakes, 16 of which were constructed on land and 27 as in-water facilities sometimes at shore-adjacent locations (GLDT 2008). GLDT also indicated that environmental studies conducted at selected CDFs around the Great Lakes indicated that CDFs are highly efficient at retaining the sediment solids and attached contaminants.

Treatability studies are not needed to assess the feasibility of these technologies. Testing could be done during the design phase to establish performance and sizing criteria (*Upland Testing Manual* [USACE 2003] and *Inland Testing Manual* [USEPA/USACE 1998]).

Offsite permitted landfills may be used to dispose PCB-containing sediments and soils. Testing data or waste characterization will be required to determine the type of landfill (e.g., TSCA, Resource Conservation and Recovery Act [RCRA], solid waste) for the disposal of PCB-containing wastes generated during the remedial actions. Treatability studies will not be conducted for offsite permitted landfills.

3.5 Summary of Candidate Technology Process Options for Possible Further Testing

As described in Section 3.4, the relative “value or need for treatability study” for the retained candidate technologies is identified in the last column of Table 2. For those where the relative value or need is “high” or “moderate,” further testing is generally recommended to be conducted during the development of an Area-specific FS if appropriate, and as determined at the time the scope and content of the FS for each Area is planned. Specific testing procedures will be evaluated, defined, and presented in the TSWPs and SAPs, as appropriate, according to the SOW (USEPA 2007). The following candidate technology process options, if considered as possible elements of proposed remedial alternatives for one or more Areas, should be considered for treatability studies:

- MNR for sediments to evaluate the fate and transport of PCBs in Area-specific settings.
- Enhanced MNR with thin-layer cap placement or with enhanced sedimentation to assess the applicability and effectiveness of the enhancement in addition to the fate and transport parameters.
- Removal (mechanical and hydraulic dredging) of sediments to evaluate bioavailability of PCBs re-introduced to the water column during removal.
- Restoration-based remediation for floodplain soils in the former impoundments to evaluate the effectiveness of the potential use of soil amendments or certain plant species.

The relative utility of treatability studies for these different technologies will depend on specific circumstances including timing of activities in each Area. If other technologies/process options for managing sediments and soils become increasingly viable based on advances in science and technologies, or are identified during the development of Area-specific FSs, they may be incorporated into the remedial alternatives presented and evaluated for their testing needs in the Area-specific FS Reports.

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Tables

Kalamazoo River Study Group
Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site
Supplemental Remedial Investigations/Feasibility Studies
Multi-Area Feasibility Study Technical Memorandum: Candidate Technologies and Testing Needs

Table 1 - Candidate Technologies and Process Options

Candidate Technology	Process Option	Retained Technology by Medium			Auxiliary Technology
		In-Stream Sediment	Bank Soil	Floodplain Soil	Ex Situ Management of Dredged or Excavated Material
No Action					
No Action	None	Retained	Retained	Retained	NA
Engineering/Institutional Controls					
Engineering/Institutional Controls	Physical Access Restriction	Retained	Retained	Retained	NA
Engineering/Institutional Controls	Land Use Restriction	NA	Retained	Retained	NA
Engineering/Institutional Controls	Activity Restrictions on Fishing and/or Hunting	Retained	Retained	Retained	NA
Engineering/Institutional Controls	Consumption Advisories	Retained	Retained	Retained	NA
Engineering/Institutional Controls	Pool Elevation Control	Retained	Retained	NA	NA
Engineering/Institutional Controls	Dredging Moratorium	Retained	NA	NA	NA
Monitored Natural Recovery (MNR)					
MNR	MNR	Retained	Retained	Retained	NA
Enhanced MNR	Enhanced MNR with Thin-layer Placement	Retained	NA	NA	NA
Enhanced MNR	Enhanced Sedimentation	Retained	NA	NA	NA
Removal					
Dredging	Mechanical Dredging in the Wet	Retained	NA	NA	NA
Dredging	Hydraulic Dredging	Retained	NA	NA	NA
Dredging	Excavation in the Dry	Retained	NA	NA	NA
Removal with or without Replacement	Mechanical Excavation with or without Backfilling	NA	Retained	Retained	NA
In Situ Containment					
Capping	In Situ Capping (ISC)	Retained	NA	NA	NA
Capping	Engineered Barrier (multi-layer)	NA	Retained	Retained	NA
Capping	Cover (soil or pavement)	NA	Retained	Retained	NA
Rechannelization	Rechannelization	Retained	Retained	NA	NA
Restoration-Based Remediation					
Restoration-based Remediation	remediation	NA	NA	Retained	NA
Erosion Control					
Bank Stabilization	Armor Stones	NA	Retained	NA	NA
Bank Stabilization	Revetment Mats	NA	Retained	Retained	NA
Bank Stabilization	Retaining Walls	NA	Retained	NA	NA
Bank Stabilization	Gabions	NA	Retained	NA	NA
Bank or Floodplain Stabilization	Vegetative Cover	NA	Retained	Retained	NA
Sediment/Solids Dewatering					
Mechanical Dewatering	Belt Filter Press or Plate and Frame Filter Press	NA	NA	NA	Retained
Gravity Settling	Stockpile	NA	NA	NA	Retained
Gravity Settling	Thickener	NA	NA	NA	Retained
Gravity Settling	Settling Basin	NA	NA	NA	Retained
Gravity Settling	GeoTube	NA	NA	NA	Retained
Stormwater Management					
Stormwater Management	Collection and Treatment	NA	NA	NA	Retained
Stormwater Management	Diversion	NA	NA	NA	Retained
Process Water Management					
Water Treatment	Onsite Treatment and Discharge	NA	NA	NA	Retained
Water Treatment	Offsite Treatment and Discharge	NA	NA	NA	Retained
Ex Situ Treatment					
Physical Treatment	Ex Situ Stabilization/ Solidification	NA	NA	NA	Retained
Chemical Treatment	Particle Separation	NA	NA	NA	Retained
Chemical Treatment	Chemical Extraction	NA	NA	NA	Retained
Thermal Treatment	Thermal Desorption	NA	NA	NA	Retained
Waste Transport					
Transportation	Barge	NA	NA	NA	Retained
Transportation	Truck	NA	NA	NA	Retained
Transportation	Rail	NA	NA	NA	Retained
Transportation	Pipeline	NA	NA	NA	Retained
Waste Disposal					
Confined Disposal Facility (CDF)	(CAD)	NA	NA	NA	Retained
CDF	On-land CDF	NA	NA	NA	Retained
Offsite Disposal Facility	Offsite Permitted Facility	NA	NA	NA	Retained

Notes:

1. NA - Not Applicable

Kalamazoo River Study Group
 Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site
 Supplemental Remedial Investigations/Feasibility Studies
 Multi-Area Feasibility Study Technical Memorandum: Candidate Technologies and the Need for Testing

Table 2 - Evaluation of Candidate Technology Testing Needs

Candidate Technology	Process Option	Applicability			Effectiveness/ Performance of Technology	Implementability of Technology	Relative PCB Removal Efficiency ²	Operation and Maintenance Requirements	Relative Costs	Relative Value or Need for Treatability Study for Purposes of the FS ^{3,4}
		Sediment	Bank Soil	Floodplain Soil						
1. No Action										
No Action	None	Applicable	Applicable	Applicable	NA ¹	NA	None	None	Low	NA
2. Engineering/ Institutional Controls										
Engineering/ Institutional Controls	Physical Access Restrictions	Applicable	Applicable	Applicable	Effective in reducing potential direct exposure to contaminated sediment and soil by human receptors.	Readily implementable. Negotiations with potentially affected landowner(s) would be necessary.	None	Periodically inspect and replace signage or repair physical barrier as needed.	Low	NA
Engineering/ Institutional Controls	Land Use Restrictions	NA	Applicable	Applicable	Effective in reducing potential direct exposure to contaminated soil by human receptors.	Readily implementable. Negotiations with potentially affected landowner(s) would be necessary.	None	In area accessible to public, periodic visits to verify land use may be recommended.	Low to medium	NA
Engineering/ Institutional Controls	Activity Restrictions on Fishing and/or Hunting	Applicable	Applicable	Applicable	Effective in reducing potential exposure of human receptors to PCBs through biota ingestion.	Implementable. Coordination with appropriate agencies is necessary.	None	Would require periodic monitoring and maintenance of signs.	Low	NA
Engineering/ Institutional Controls	Consumption Advisories	Applicable	Applicable	Applicable	Effective in reducing potential exposure of human receptors to PCBs through biota ingestion.	Implementable. Coordination with appropriate agencies are necessary.	None	Would require periodic monitoring and maintenance of signs.	Low	NA
Engineering/ Institutional Controls	Pool Elevation Control	Applicable	Applicable	NA	Moderately effective in reducing potential exposure of ecological receptors by minimizing the resuspension of contaminated sediment.	Implementable, but relies on the dam and impoundment owners to operate and maintain the dams in compliance with applicable laws and regulations.	None	Would require long-term operation and maintenance by the dam and impoundment owners.	Medium	NA
Engineering/ Institutional Controls	Dredging Moratorium	Applicable	NA	NA	Somewhat effective in reducing potential exposure of human and ecological receptors by controlling scouring and resuspension of contaminated sediment.	Implementable. Coordination with appropriate agencies are necessary.	None	No operation and maintenance is required.	Low	NA

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Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site
Supplemental Remedial Investigations/Feasibility Studies
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		Sediment	Bank Soil	Floodplain Soil						
3. Monitored Natural Recovery (MNR)										
MNR	MNR	Applicable	Applicable	Applicable	Effective in a variety of environments over time by utilizing ongoing natural processes.	Readily implementable and minimally intrusive. Would require testing such as trend analysis to assess Area-specific implementability.	Low	Would rely upon baseline and performance monitoring to assess performance and effectiveness.	Low to medium	High (continuation of long-term monitoring)
Enhanced MNR	Enhanced MNR with Thin-Layer Placement	Applicable	NA	NA	Effective in a variety of environments over time. Improves on MNR through placement of a thin layer of clean soil or sediment, which isolates PCB-containing sediment and soil from potential human and ecological receptors.	Readily implementable. Would require testing such as trend analysis to assess Area-specific implementability.	Low	Would rely upon baseline and performance monitoring to assess performance and effectiveness.	Low to medium	High (continuation of long-term monitoring)
Enhanced MNR	Enhanced MNR with Enhanced Sedimentation	Applicable	NA	NA	Effective in low-energy aquatic environments. Improves on MNR through constructing dams or other engineered structures to alter the rate of sedimentation and increase the rate of natural recovery, which subsequently reduce the exposure to PCB-containing sediment and soil from potential human and ecological receptors.	Technically implementable, but could alter local habitat and river use. Would require impact assessment on surface water elevations, channel depth, and stability of added sediment layer.	Low	Would rely upon baseline and performance monitoring to assess performance and effectiveness.	Low to medium	High (continuation of long-term monitoring)
4. Removal										
Dredging	Mechanical Dredging in the Wet	Applicable	NA	NA	Effective in removing PCBs in the long-term, but may increase short-term exposure due to technical limitations.	Implementability would depend on site characteristics.	Medium to high	Would not typically require long-term operation and maintenance. Post-dredging testing of effectiveness may be performed.	Medium to high	High
Dredging	Hydraulic Dredging	Applicable	NA	NA	Effective in removing PCBs in the long-term, but may increase short-term exposure due to technical limitations.	Implementability would depend on site characteristics. Difficulties have been noted in achieving low residual PCB concentrations in surface sediments. Effectiveness could be limited by presence of debris.	Medium to high	Would not typically require long-term operation and maintenance. Post-dredging testing of effectiveness may be performed.	Medium to high	High
Dredging	Excavation in the Dry	Applicable	NA	NA	Effective in removing PCBs in the long-term, but may increase short-term exposure of construction workers due to intrusive activities.	Implementability would depend on site characteristics. Difficulties may be encountered in achieving low residual PCB concentrations in surface sediments when river bottom is not completely dewatered. Effectiveness could be limited by depth of water column and flood events.	Medium to high	Would not typically require long-term operation and maintenance. Post-dredging testing of effectiveness may be performed.	Medium to High	Low
Removal with or without Replacement	Mechanical Excavation with or without Backfilling	NA	Applicable	Applicable	Effective in reducing and controlling a source of PCB loading to the Kalamazoo River and reducing potential exposure by human receptors to PCBs through removal of impacted bank or floodplain soils.	Implementable. Difficulties may be encountered in roadway access to forest and wetland areas. Negotiations with potentially affected landowner(s) would be necessary.	Medium to high	Would not typically require long-term operation and maintenance.	Medium to high	Low

Kalamazoo River Study Group
 Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site
 Supplemental Remedial Investigations/Feasibility Studies
 Multi-Area Feasibility Study Technical Memorandum: Candidate Technologies and the Need for Testing

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Candidate Technology	Process Option	Applicability			Effectiveness/ Performance of Technology	Implementability of Technology	Relative PCB Removal Efficiency ²	Operation and Maintenance Requirements	Relative Costs	Relative Value or Need for Treatability Study for Purposes of the FS ^{3,4}
		Sediment	Bank Soil	Floodplain Soil						
5. <i>In Situ</i> Containment										
Capping	<i>In situ</i> Capping (ISC)	Applicable	NA	NA	Effective in isolating PCB-containing sediment from potential exposure by human and ecological receptors.	Implementable in most areas. May need to be applied with removal to maintain flood storage capacity.	Low to medium	Would require institutional controls, long-term monitoring and maintenance (if needed) to verify the effectiveness of the cap.	Medium to high	Low
Capping	Engineered Barrier (multi-layer cover)	NA	Applicable	Applicable	Effective in isolating PCB-containing soils from potential exposure by human and ecological receptors.	Implementable in most areas. May need to be applied with removal to maintain flood storage capacity.	Low to medium	Would require institutional controls, long-term monitoring and maintenance (if needed) to verify the effectiveness of the cap.	Medium to high	Low
Capping	Cover (soil or pavement or other material)	NA	Applicable	Applicable	Effective in isolating PCB-containing soils from potential exposure by human and ecological receptors.	Implementable in most areas. May need to be applied with removal to maintain flood storage capacity. Soil strength enhancement may be necessary if a pavement cap is installed. Cover soil may be amended to enhance the fertility of vegetation growth.	Low to medium	Would require institutional controls, long-term monitoring and maintenance (if needed) to verify the effectiveness of the cap.	Medium	NA
Rechannelization	Rechannelization	Applicable	Applicable	NA	Effective in isolating PCB-containing soils from potential exposure by human and ecological receptors	Implementable in areas where property is available and river configuration is appropriate (e.g., oxbows.) Can be implemented with standard construction methods.	Low to medium	Would require long-term monitoring and maintenance to verify effectiveness.	Medium to high	NA
6. Restoration-Based Remediation										
Restoration-based Remediation	Soil Cover, Soil Amendments, or Phyto-remediation	NA	NA	Applicable	Effective in reducing bioavailability, mobility, or toxicity of PCBs in floodplain soil by placing or mixing soil, soil amendments, or fertility agents in the floodplain areas in conjunction with improving the fertility and growth of vegetation and desirable habitats.	Implementable in areas such as former impoundments. Ongoing research may support Phyto-remediation as a means of bio-dechlorination of PCB. May need to apply soil amendments to enhance soil fertility and vegetation growth.	Low to medium	Would require institutional controls, long-term monitoring and maintenance (if needed) to verify the effectiveness of the cap.	Medium	Moderate

Kalamazoo River Study Group
Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site
Supplemental Remedial Investigations/Feasibility Studies
Multi-Area Feasibility Study Technical Memorandum: Candidate Technologies and the Need for Testing

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		Sediment	Bank Soil	Floodplain Soil						
7. Erosion Control										
Bank Stabilization	Armor Stone	NA	Applicable	NA	Effective in isolating contaminated bank soil from eroding and subsequent transport to the Kalamazoo River.	Implementable. May require soil removal prior to installation of armor stones.	Low to medium	Would require institutional controls, long-term monitoring and maintenance.	Low to medium	Low
Bank Stabilization	Revetment Mats	NA	Applicable	Applicable	Effective in isolating contaminated bank soil and floodplain soil from eroding and subsequent transport to the Kalamazoo River.	Implementable. May require soil removal prior to installation of revetment mats and other cover layer(s) as well as an anchoring mechanism.	Low to medium	Would require institutional controls, long-term monitoring and maintenance.	Low to medium	Low
Bank Stabilization	Retaining Walls	NA	Applicable	NA	Effective in isolating contaminated bank soil from eroding and subsequent transport to Kalamazoo River.	Implementable. May require soil removal prior to installation of retaining walls and supporting structures.	Low to medium	Would require institutional controls, long-term monitoring and maintenance.	Medium	Low
Bank Stabilization	Gabions	NA	Applicable	NA	Effective in isolating contaminated bank soil from eroding and subsequent transport to Kalamazoo River.	Implementable. May require soil removal prior to placement of gabions.	Low to medium	Would require institutional controls, long-term monitoring and maintenance.	Medium	Low
Bank or Floodplain Stabilization	Vegetative Cover	NA	Applicable	Applicable	Effective in reducing bank or floodplain soil erosion from gently sloped banks.	Implementability is limited by river conditions. Time is required to establish the vegetation.	Low to medium	Would require long-term monitoring and maintenance.	Low to medium	Low
8. Sediment/Solids Dewatering										
Mechanical Dewatering	Belt Filter Press or Plate and Frame Filter Press	Applicable	NA	NA	Effective in reducing disposal volume by removing liquid from dredged material.	Implementable as part of sediment/solid management in conjunction with dredging.	NA	Would not require long-term monitoring or maintenance.	Medium	Low
Gravity Settling	Stockpile	Applicable	Applicable	NA	Effective in reducing disposal volume by removing liquid from dredged material.	Implementable as part of sediment/solid management in conjunction with dredging. Would require relatively significant land area for staging.	NA	Would not require long-term monitoring or maintenance.	Low	Low
Gravity Settling	Thickener	Applicable	NA	NA	Effective in reducing disposal volume by removing liquid from dredged material.	Implementable as part of sediment/solid management in conjunction with dredging.	NA	Would not require long-term monitoring or maintenance.	Medium	Low
Gravity Settling	Settling Basin	Applicable	NA	NA	Effective in reducing disposal volume by removing liquid from dredged material.	Implementable as part of sediment/solid management in conjunction with dredging.	NA	Would not require long-term monitoring or maintenance.	Medium	Low
Enhanced Gravity Settling	GeoTubes	Applicable	NA	NA	Effective in separating solids of hydraulically- dredged materials from liquids for subsequent disposal.	Implementable as part of sediment/solid management in conjunction with hydraulic dredging. Would typically require addition of polymers.	NA	Would not require long-term monitoring or maintenance.	Medium to high	Low

Kalamazoo River Study Group
 Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site
 Supplemental Remedial Investigations/Feasibility Studies
 Multi-Area Feasibility Study Technical Memorandum: Candidate Technologies and the Need for Testing

Table 2 - Evaluation of Candidate Technology Testing Needs

Candidate Technology	Process Option	Applicability			Effectiveness/ Performance of Technology	Implementability of Technology	Relative PCB Removal Efficiency ²	Operation and Maintenance Requirements	Relative Costs	Relative Value or Need for Treatability Study for Purposes of the FS ^{3,4}
		Sediment	Bank Soil	Floodplain Soil						
9. Stormwater Management										
Stormwater Management	Collection and Treatment	Applicable	Applicable	Applicable	Effective in containing and treating stormwater runoff that contacts PCB-containing material during remedial construction.	Readily implementable.	High	Would require operation and maintenance of collection and water treatment system during the course of remedial construction. Monitoring data may be required to meet stormwater discharge permit requirements.	Medium	Low
Stormwater Management	Diversion	Applicable	Applicable	Applicable	Effective in preventing stormwater contact with PCB-containing material.	Readily implementable.	NA	May require filtration pretreatment prior to discharge of diverted stormwater runoff per stormwater discharge permit	Low	NA
10. Process Water Management										
Water Treatment	Onsite Treatment Plant	Applicable	Applicable	Applicable	Effective in removing PCBs from processed water prior to discharge.	Readily implementable. The water treatment system may consist of components such as chemical flocculation and settling to remove particle-bound PCBs, filtration to remove fine particulates, and activated carbon polishing.	Medium to high	Monitoring data may be required to meet water discharge permit requirements.	Low to medium	Low
Water Treatment	Offsite Treatment Plant	Applicable	Applicable	Applicable	Effective in removing PCBs from processed water to meet applicable discharge requirements at offsite disposal facility.	Readily implementable. May be limited by offsite treatment facility availability and capacity.	High	No onsite monitoring is required for this option. Data may be required to establish offsite treatment profile.	Low to medium	Low
11. Ex Situ Treatment										
Physical Treatment	Ex Situ Stabilization/ Solidification	Applicable	Applicable	Applicable	Effective in reducing mobility and/or toxicity of contaminants in sediment or soil through addition of binding agents such as cement and fly ash.	Implementable in conjunction with sediment or soil removal technologies.	Low	No long-term monitoring or maintenance required. May require post-treatment testing to verify effectiveness.	Medium to high	Low
Physical Treatment	Particle Separation	Applicable	Applicable	Applicable	Effective in reducing the volume of sediment and soil for subsequent treatment and disposal by physically separating finer-grained particles from coarser-grained particles. The finer-grained particles tend to contain higher PCB concentrations.	Implementable in conjunction with sediment or soil removal technologies.	Medium	No long-term monitoring or maintenance necessary.	Medium to high	Low
Chemical Treatment	Chemical Extraction	Applicable	Applicable	Applicable	Effective in separating contaminants from sediment or soil through solvent extraction.	Implementable in conjunction with sediment or soil removal technologies.	Medium to high	No long-term monitoring or maintenance.	High	Low
Thermal Treatment	Thermal Desorption	Applicable	Applicable	Applicable	Effective in separating volatile and semivolatile contaminants from sediment or soil.	Implementable in conjunction with sediment or soil removal technologies.	Medium to high	No long-term monitoring or maintenance.	High	Low

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		Sediment	Bank Soil	Floodplain Soil						
12. Waste Transport										
Transportation	Barge	Applicable	Applicable	Applicable	Effective in wet or hydraulic dredging.	Implementable where site condition is suitable for barge operation.	NA	NA	Low	NA
Transportation	Truck	Applicable	Applicable	Applicable	Effective in near-shore excavation or as a component of other operations.	Readily implementable.	NA	NA	Low to medium	NA
Transportation	Rail	Applicable	Applicable	Applicable	Effective if sediment and soil volume is large and cost is effective.	Implementable where rail access is feasible.	NA	NA	Low	NA
Transportation	Pipeline	Applicable	NA	NA	Effective in transporting large volume of hydraulically-dredged materials.	Implementable in conjunction with hydraulic dredging operations.	NA	NA	Low	NA
13. Waste Disposal										
Confined Disposal Facility (CDF)	In-water CDF or Confined Aquatic Disposal (CAD)	Applicable	NA	NA	Effective in isolating PCB-containing sediment from potential exposure by human and ecological receptors.	Implementable. Most cost-effective with large volume of sediments.	Low to medium	Would require long-term monitoring and maintenance of the CDF components.	Medium	NA
CDF	On-land CDF	Applicable	Applicable	Applicable	Effective in isolating and containing PCB-containing sediment from potential exposure by human and ecological receptors.	Implementable. Ability to locate and purchase sufficient land in vicinity is critical.	Low to medium	Would require long-term monitoring and maintenance of the CDF components.	Medium to high	NA
Offsite Disposal Facility	Offsite Permitted Facility	Applicable	Applicable	Applicable	Effective in removing PCB-containing material from Site.	Implementable. May be limited by offsite landfill availability and capacity. TSCA or solid waste landfill depending on PCB concentrations.	Medium	NA	Low to high	NA

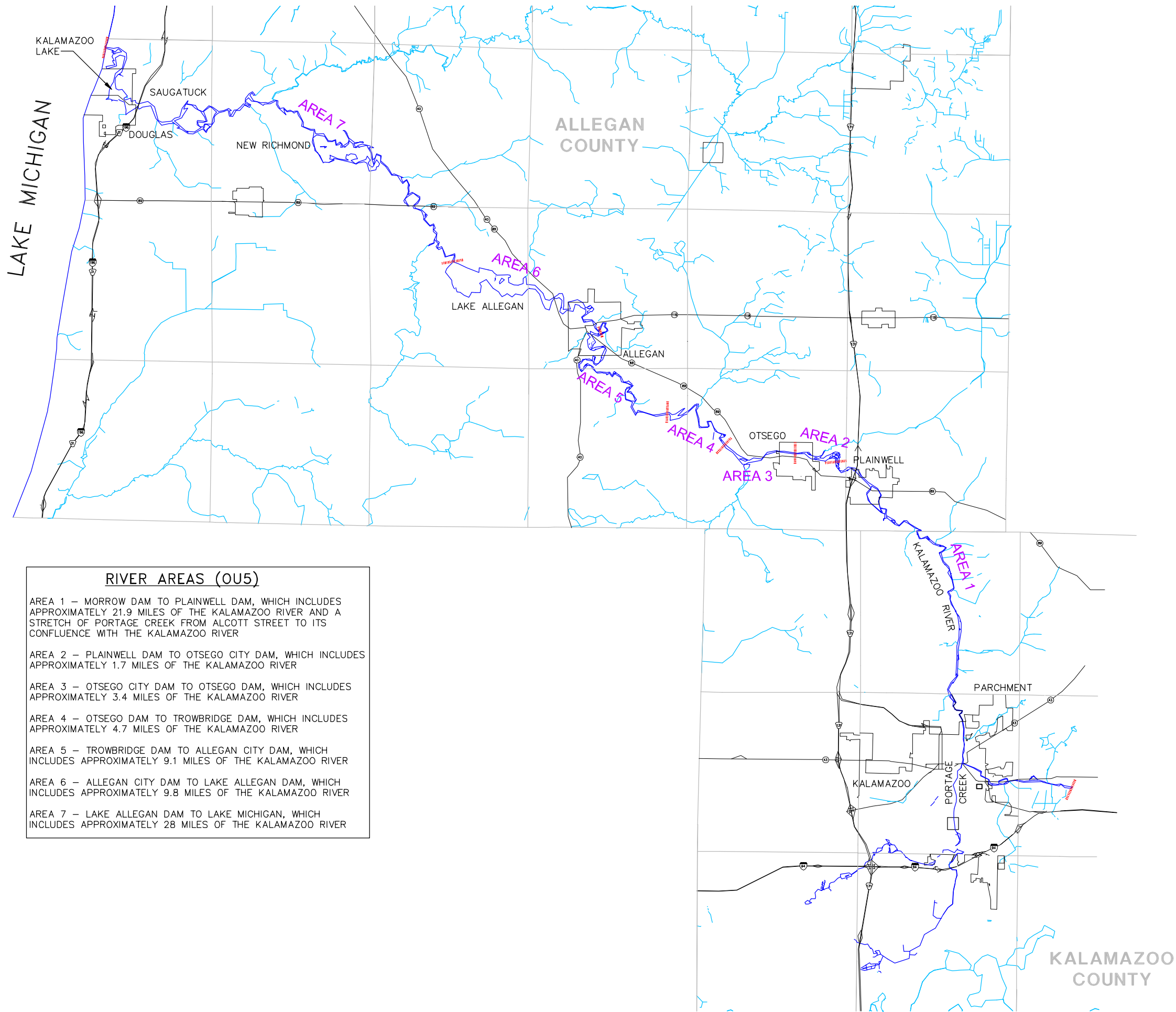
Notes:

1. NA - Not Applicable
2. PCB Removal Efficiency expresses the relative degrees of PCB removal or reduction in terms of mobility and/or bioavailability and the resulting mitigation of potential exposure risks to human and ecological receptors at the Site.
3. Ranking: Low = Low value or potential benefit, unlikely to provide information that would affect evaluation of technology or process option in the FS; Moderate = Some or moderate value to the FS, likely to improve basis for evaluation of technology or process option in the FS; High = Relatively higher value, may substantially improve basis for evaluation of the technology or process options in cases where additional data needs exist.
4. Bench or pilot tests may be performed for some of the selected remedial process options during the remedial design phase for equipment sizing and testing.

Figure

CITY: SYR DM/GROUP: 86 DB: RLP LD: AM: PD: TM: TR: LYRON: OFF: REF: G:\CAD\DAC\T0006452\0000000640\DWG\MAFSTM64524B03.DWG LAYOUT: 1.1 SAVED: 1/16/2008 2:12 PM ACADVER: 17.05 (UNS TECH) PAGES: 17 PLOT: 1/16/2008 2:12 PM BY: PETRIE, RICH

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RIVER AREAS (OU5)

AREA 1 – MORROW DAM TO PLAINWELL DAM, WHICH INCLUDES APPROXIMATELY 21.9 MILES OF THE KALAMAZOO RIVER AND A STRETCH OF PORTAGE CREEK FROM ALCOTT STREET TO ITS CONFLUENCE WITH THE KALAMAZOO RIVER

AREA 2 – PLAINWELL DAM TO OTSEGO CITY DAM, WHICH INCLUDES APPROXIMATELY 1.7 MILES OF THE KALAMAZOO RIVER

AREA 3 – OTSEGO CITY DAM TO OTSEGO DAM, WHICH INCLUDES APPROXIMATELY 3.4 MILES OF THE KALAMAZOO RIVER

AREA 4 – OTSEGO DAM TO TROWBRIDGE DAM, WHICH INCLUDES APPROXIMATELY 4.7 MILES OF THE KALAMAZOO RIVER

AREA 5 – TROWBRIDGE DAM TO ALLEGAN CITY DAM, WHICH INCLUDES APPROXIMATELY 9.1 MILES OF THE KALAMAZOO RIVER

AREA 6 – ALLEGAN CITY DAM TO LAKE ALLEGAN DAM, WHICH INCLUDES APPROXIMATELY 9.8 MILES OF THE KALAMAZOO RIVER

AREA 7 – LAKE ALLEGAN DAM TO LAKE MICHIGAN, WHICH INCLUDES APPROXIMATELY 28 MILES OF THE KALAMAZOO RIVER

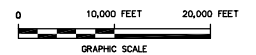


NOTES:

1. ALLEGAN AND KALAMAZOO COUNTY MAPPING OBTAINED FROM MICHIGAN RESOURCE INFORMATION SYSTEM.

LEGEND:

--- LIMITS OF RIVER AREAS WITHIN OU5



KALAMAZOO RIVER STUDY GROUP
ALLIED PAPER, INC./PORTAGE CREEK/KALAMAZOO RIVER
SUPERFUND SITE
**MULTI-AREA FEASIBILITY STUDY
TECHNICAL MEMORANDUM**

AREAS OF THE SITE



FIGURE
1